UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

March 24, 1993

OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

EPA-SAB-CAACAC-LTR-93-006

Honorable Carol M. Browner
Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Subject: Science Advisory Board's review of the Office of Policy, Planning, and Evaluation 's (OPPE) and the Office of Air and Radiation's (OAR) progress on the retrospective study of the impacts of the Clean Air Act.

Dear Ms. Browner:

On December 22, 1992, the Clean Air Act Compliance Analysis Council (CAACAC) met to address a variety of issues related to the retrospective and prospective Clean Air Act (CAA) impact studies required by Section 812 of the CAA amendments of 1990. The discussions at that meeting reflected both the Charge provided to the Council and important issues raised by the background documents that were also provided in advance.

The four major topics covered by the Charge and the Council's response follow. The letter closes with two more general observations.

1) Estimation of Costs and Macromodeling

At our earlier meeting (April 14, 1992), the general equilibrium methodology that the Agency planned to used was discussed at length. While we felt, and continue to feel, that the basic approach being followed is sound, our letter report to Administrator Reilly of September 30, 1992 (EPA-SAB-CAACAC-LTR-92-019) was devoted mainly to detailing several of our most important concerns with this methodology. At this meeting, in response to these concerns, we were given a document summarizing the use of this methodology to analyze CAA costs (*Direct Compliance Costs and Impacts of the Clean Air Act on U.S. Economic Activity, 1970-1990* (DRAFT)), which dealt with only one of our concerns (the use of cost data as lump sum taxes). When we

complained that our strongly expressed views had been ignored, we were informed that our concerns had simply not been communicated in any form to the contractor who drafted this document.

The Council finds this disregard for its professional opinions absolutely unacceptable. The CAACAC is composed of busy people who are attempting to assist the Agency in the production of sound and credible retrospective and prospective studies of the impact of the CAA. If the Agency is uninterested in producing such a study, or in our assistance, we all have much more productive uses for our time. In addition, Section 812 requires the CAACAC to evaluate the final study for the Administrator and, implicitly, for the Congress. All the Members of this Council take this responsibility seriously. The CAACAC reiterates all the concerns raised in its earlier letter and earnestly hopes they are dealt with before its next meeting.

In terms of the materials provided, the data on direct costs and the use of those data in the modelling process appear to be generally sensible. The main exception is the treatment of mobile source pollution control costs. In its report, *Environmental Investments: The Cost of a Clean Environment* (U.S. EPA, 1990), which was the primary source of cost data for the retrospective study, the Agency shows mobile source costs of about $8 billion per year. Other sources have produced much higher estimates. Converting the per-vehicle costs in *The Regulation of Air Pollution Emissions from Motor Vehicles* (White, 1982) into a total fleet cost in 1991 dollars yields an figure of about $21 billion. Similarly, the estimates in *Regulating the Automobile* (Crandall et al., 1986), translate into a total cost of $19.5 billion. Finally, the Bureau of Economic Analysis (U.S. Department of Commerce, 1992) gives total annual costs for mobile source pollution control of about $15 billion in 1990 in current dollars. **This quantitatively important discrepancy must be resolved if the Council is to have any confidence at all in the results of this study.** Apparently, EPA is alone in assuming that the wide-spread use of electronic fuel injection and ignition would never have materialized but for the requirement that catalytic converters be installed. This may nonetheless be a reasonable assumption, but at the very least it should be defended and its impact on the final results must be clearly indicated.

In principle, effects such as decreases in worker productivity and increases in medical care expenditures that would occur in the no control scenario should affect Gross Domestic Product (GDP). We do not believe, however, that it is likely to be productive to attempt formally to "close the loop" by incorporating such effects in the

general equilibrium modelling. As we understand the Jorgenson/Wilcoxen (J/W) model, it may be also impossible for it to show impacts on the pollution control industry, narrowly defined, since such impacts importantly reflect changes in the detailed composition of investment goods produced.

As we understand it, the J/W model holds constant the nominal dollar value of net foreign investment in the U.S. Changes in the U.S. price level thus alter the real supply of foreign savings in the model, while changes in the foreign exchange rate alter the foreign currency value of net investment flows from abroad to the U.S. While it would of course be desirable in principle to model the behavior of foreign investors explicitly, we doubt the feasibility of developing a credible model of this sort on the basis of current knowledge. (Also, the year-to-year changes produced by the J/W model are intrinsically unreliable, as we noted in our earlier letter, yet expectations about such changes are critical determinants of investor behavior in the no regulation scenario.) We do not believe that failure to build in a supply curve of foreign investment necessarily biases CAA cost estimates upward, as the charge suggests, since the CAA arguably made investment in the U.S. less attractive on balance. At the very least, however, sensitivity to alternative plausible assumptions should be explored. These include, at least, holding the real dollar value of these flows constant and holding their foreign currency value constant.

We were asked for comments on the planned assumption that all industry-reported compliance costs are attributable to the Federal Clean Air Act and that no additional State or local regulations would have been developed under the no control scenario. While one can certainly argue with this assumption on a variety of grounds, we see no workable, defensible alternative. Readers of the CAA impact study should be made clearly aware of this assumption and its qualitative implications.

2) Emissions Modeling

In general, the CAACAC believes that it is appropriate to estimate emissions by linking an integrated model set of sectoral models to a general equilibrium macro model. We also recognize the necessity of using off-the-shelf models in this analysis. We urge the Agency to seek ways to use existing data sets to improve the credibility and likely performance of the Trends methodology in this study; it is clearly one of the weakest links in the analytical chain. The Council strongly prefers the assumptions and approach (including, in particular, the treatment of State Implementation Plans

(SIP) and state-by-state calibration) underlying the ICF, Inc. Coal and Electric Utilities Model (CEUM) analysis to those that shaped the Argonne Argus Model work on electric utilities.

The Council is particularly concerned that emissions of air toxics be treated carefully. Without being specifically targeted toward the reduction of air toxics, the CAA has had major impacts on these emissions through, among other things, controls of volatile hydrocarbon emissions, the switch to unleaded gasoline, and controls on particulate emissions. The significant health effects of lead emissions alone suggest that failure to account properly for these impacts could substantially distort estimates of total retrospective CAA benefits.

It is also important to deal explicitly with emissions of trace metals from coal-fired power plants. Metals that are volatile at the temperatures in the combustion zone evaporate. With the exception of mercury, which remains a vapor, they recondense as ultrafine particles as temperatures decline in the exiting gas stream. These particles, composed of the oxides of arsenic, cadmium, copper, lead, and zinc, are too small to be collected by "bag house" fabric filters or electrostatic precipitators. They are discharged, along with mercury vapor, from the stack in proportion to their content in the coal, and their small size results in widespread dispersion, much like mercury vapor. These emissions can, collectively, form a major source of rising background levels of trace metals in the environment. These emissions have been associated with rising levels of mercury in Great Lakes fish, and small elevations in background levels of non-threshold pollutants such as arsenic, and toxicants such as lead, could lead to calculable elevations in human mortality and morbidity.

3) Uncertainty Analysis

We commend the Agency for its intention to produce a report that includes quantitative measures of uncertainty associated with each major component of the analysis, identification of key policy-relevant uncertainties, and implications for the aggregate level of uncertainty associated with the final net benefit levels. The statistical characteristics of input data, analyzed in some of the documents referred to us, can usefully be employed in this analysis. The Council urges the Agency not to neglect in its analysis or presentation those elements of uncertainty that cannot easily be quantified, however. In particular, uncertainties associated with model specification (including, as noted in our earlier letter, the treatment of technical change) should not

be neglected. Similarly, serious debates regarding input data (see discussions of mobile source abatement costs and net foreign investment, above) should in most cases be treated as reflecting serious uncertainties.

The CAACAC recommends that the Agency not rely heavily on the hierarchically partitioned assessment (HPA) model in this study. The HPA appears to be essentially a spreadsheet accounting system that handles the straightforward, mechanical propagation of confidence intervals through multiplicative and additive interactions. It cannot substitute for the use of Monte Carlo methods, which are necessary to analyze the J/W model and other complex nonlinear models (where possible, we would recommend that the study deal analytically with probability distributions, not simply confidence intervals). Nor can it substitute for the use of judgement in the analysis of difficult-to-quantify uncertainties of the sort discussed in the preceding paragraph. And as an analytical tool, its power is limited.

An important output from analysis of the uncertainties involved in the retrospective study should be improved research priorities for the prospective study. Each model in the set employed in this study was created for a purpose other than its current use. As the Council reviewed these models, the compromises they embody became evident, as did some possible strategies for reducing the adverse impact of these compromises on the prospective and retrospective analyses. Because time and resource availabilities preclude implementing all of these suggestions, a strategy of setting priorities is essential. Such a strategy can significantly improve the prospective study, which will depend on the same basic set of models. We recommend an approach that considers both the impact of improved information on the ultimate analysis and the cost of acquiring that information. The first step could be accomplished in large part by Monte Carlo studies, which would identify the crucial areas of the analysis. The second step would involve (probably subjective) judgements about the costs of acquiring better information. Putting these pieces together should provide a basis for targeting future efforts.

4) Estimating Economic Benefits & Damages

The Council received for review three draft studies prepared for EPA by Industrial Economics, Incorporated (IEc., hereafter). These drafts constitute surveys of the main areas pertinent to benefit assessment for the Clean Air Act. The three studies together review estimates of the values of reduced mortality, reduced

morbidity, improved visibility, improved surface walter quality, improved crop yields, reductions in forest decline, and reductions in materials damage.

In these comments, we first discuss the general issue of the treatment of different economic values taken from different studies. We then take up, in turn, the treatment of each of the seven categories of air pollution control benefits in the IEc reports.

a) The Weighing of Value Estimates

The major issue raised in any such undertaking is how one should weight the previous studies. The approach undertaken by IEc is similar to that of classical statisticians, although with some amendments. In particular, their reports are for the most part agnostic with respect to the quality of particular studies except with respect to some extreme judgments.

For example, in the case of their mortality valuation survey, a number of studies are not considered at all because they are inappropriate or are not scientifically sound. Other than some partial screening of this type, all studies tend to be given equal weight. The draft valuation document for the value of life discusses a variety of descriptive statistics, such as the arithmetic and geometric means of the value of life estimates found in the literature. For some of the other benefit components the weighing scheme is based on the number of observations in the different studies.

Although the Council views various kinds of mechanical weighing schemes such as this as being useful, it would be more informative (from the standpoint of EPA decision making) to have statements in these reports regarding the judgements of IEc as to which of the studies are the most reliable. For example, if one study is superior to another in terms of its quality of research design, then presumably EPA should be advised to place greater weight on its results than on earlier studies that were not as sound. It will, of course, not always be feasible to give EPA a single, specific best estimate in every case. Earlier studies and studies with some research imperfections usually should receive some consideration, though much less consideration than superior studies. However, IEc should provide EPA officials with sufficient information so that EPA can make informed judgements as to which studies should guide the benefit assessment process.

b) Value of Life Estimates

This report represents a survey of the three principal surveys of the statistical value of life that have been undertaken in the literature, those of Miller (1990), Fisher *et al.* (1989), and Viscusi (1992). Each of these studies presented a range within which the value of life was thought to lie.

IEc placed the lowest weight on the Miller study because it was viewed by them as being less reliable than the other two studies (due to various adjustments that were made to the original estimates). The Council concurs with this decision– in addition, IEc's report places the greatest weight on the Viscusi study since it is broader and more comprehensive than the Fisher *et al.* (1989) study. Much of the IEc report's analysis focuses on the distribution of estimates of the value of life from the Viscusi (1992) study (report Exhibit 1) and discusses the implications of the different approaches to the value of life based on the extensive survey of these studies in his Exhibit A-1.

How one goes from this literature to EPA policy on benefit evaluation is not a straightforward task. The first issue involves selecting the most pertinent estimate of the value of life for benefit assessment. This may not necessarily mean picking the best labor market estimate of the value of life. These studies pertain to the value of life of particular groups of workers, some of whom are in very high risk jobs and will have a lower value of life than would the typical individual protected by EPA policies. For the most part, EPA regulations protect groups in the population who are incurring risks involuntarily. As a consequence, one should not use the value of life estimates from studies of workers in very high risk jobs. Studies of more representative groups of workers are likely to be more pertinent.

In addition, although there have been a large number of studies of the value of life, these are not all of equal quality in terms of their econometric approach. Some studies control for other non-risk attributes of the job as well as for nonfatal injuries, whereas others do not. The risk variables employed differ, and the inclusion of workers, compensation benefits in the wage equation also affects the results. It would be useful from the standpoint of EPA decision makers to have more judgments made in the IEc report as to which studies they view as being superior. In the current draft, 26 studies are given equal weight, and both contingent valuation studies and labor market studies are treated equivalently. Nevertheless the Council views the overall

value of life figure emphasized in this report, about five million dollars, as being a reasonable figure.

Even if one agrees on this estimate, there still remain important research issues for EPA that have not yet been resolved. The value of life estimates pertain to deaths due to job-related fatalities as opposed to illnesses. If the main class of deaths that will be averted through EPA policies consist of cases of cancer, how should these fatalities be valued as compared with those resulting from an acute injury? Work on this issue using contingent valuation methods has been completed for the OPPE and could be referenced. The value of life for preventing a case of cancer is not too dissimilar from the value of an actual injury such as an automobile fatality.

A more important open issue pertains to the duration of life being lost. Workers who are killed on the job at age 40 are clearly losing much more life than are the elderly whose deaths might be accelerated by air pollution. How should EPA confront this difference? The report suggests some age adjustments based on estimates in the literature as well as possible *ad hoc* adjustments that might be used. The Council does not view this issue as being satisfactorily resolved from the standpoint of EPA benefit assessment. We urge that EPA continue to undertake original work on this topic, beyond that is required for this report. Addressing the duration of life issue clearly is going to be central to the benefit assessment values used for the Clean Air Act.

c) Value of Morbidity Estimates

The IEc *Review of Existing Morbidity Estimates* draws heavily on an earlier literature review by Weitzel (1990). The Council agrees with the general approach to morbidity valuation, which is that it should be based on beneficiaries' willingness to pay for reductions in various measures of morbidity. However, the Council has some concerns about the measures of morbidity that are being valued.

The report considers the valuation of symptom days for a variety of illnesses. However, it will not necessarily be the case that willingness to pay for avoiding spells of illnesses will be additive over symptom days. For example, an individual who is willing to spend $20 to avoid a head cold for one day may not be willing to spend $200 to avoid a 10-day episode of this head cold. In addition, what is being valued are risks of various forms of morbidity, not sure events. For minor health effects such

as very temporary illnesses, this distinction is not likely to be of significance. However, for major long-term health impacts, such as chronic bronchitis, one should adopt the same benefit assessment approach that is used in the value of life literature. What should be valued are statistical episodes of morbidity events, and not sure outcomes. The failure of most of the studies in the literature to make this distinction should be noted as part of the review by IEC.

The outcome being valued in the benefit assessment process hinges at least in part on the information on morbidity that is available. For example, if the information pertains to the total days of illness prevented without making any distinctions regarding the length of the individual spells of illness, one would need some procedure to obtain an estimate of the value per day of that illness for the types of spells that are involved. Also, the measures of value chosen must correspond to the types of morbidity effects predicted with the air pollution/health effects dose-response functions. Other measures that are relevant include numbers of emergency room visits, respiratory hospital admissions, restricted activity days, respiratory restricted activity days, and lost work days.

The report does not deal adequately with the valuation of chronic disease. For example, there have been two studies of chronic bronchitis prepared for OPPE -- one by Viscusi *et al.* (1991), which focuses on a contingent valuation of healthy respondents, and a study by Krupnick and Cropper (1992) which administers the Viscusi and Magat survey to a sample of individuals who have experienced chronic bronchitis. These studies also deal with more extended spells of the illness than symptom days and, as a consequence, utilize a theoretically correct approach to benefit assessment.

The Council regards the decision to focus only on estimates based on contingent valuation (CV) as unfortunate. The contingent valuation technique is controversial for reasons which are identified in the IEc report. Also, there are studies based on other approaches, such as the cost of illness approach, which might provide a useful basis for comparison with the results reported here or as a supplement since, as the IEc report points out, CV respondents might not take costs covered by medical insurance into account in their bids. Regarding cost of illness estimates, in addition to the report by Abt Associates (1991) cited in the IEc report, there is other recent work by Krupnick and Cropper (1990) on the cost of chronic heart and lung disease.

There are also some areas of morbidity effects that are not given adequate treatment in this report. The value of lost days of work is an issue about which there has been substantial research which could be addressed in this report. A more open issue is the value of lost time at school, which would be among the classes of issues that IEc should highlight as warranting further research.

Finally, there is nothing in this report on the valuation of the health effects of elevated blood lead levels. Given the importance of the adverse health effects of elevated blood levels for both adults and children, and given the substantial decline in lead emissions and in blood lead levels following the phase down of lead in gasoline, this could be a very important category of benefits in the overall Assessment.

d) The Valuation of Visibility

The IEc report on visibility relies heavily on the results of studies utilizing contingent valuation. This research approach is controversial and warrants separate scrutiny by another Science Advisory Board panel. At the very least, from the standpoint of this report, there should be additional caution raised in that the benefit estimates should not be utilized until the reliability of the underlying study has been carefully evaluated. In that regard, more can be said about the quality of the existing studies than is said in the IEc report.

The general assessment with respect to visibility benefits is that the estimates in the original study by Tolley *et al.* (1986) were high. Even though the more recent estimates by Schulze *et al.* (1981) are lower, a number of open questions remain. Chicago residents' use value of visibility cited in Schultze's study is less than half of their non-use value for visibility at the Grand Canyon. The Council found such results surprising and, at the very least, warranting further scrutiny of the reliability of the studies.

Non-use valuation is a much more important issue than this estimate of $84 of non-use value of the Grand Canyon might suggest. When small amounts such as this are aggregated over, for example, 100 million U.S. households, then the societal benefit estimate becomes quite substantial indeed.

Another issue with respect to the visibility studies is the extent to which they are able to disentangle the valuation of visibility from the valuation of other effects

associated with air pollution such as changes in health. Even with carefully structured surveys, respondents may be incorporating some of their health concerns when they give their responses to the visibility assessment question.

e) Surface Water Quality

This section of the IEc report deals with the impacts of atmospheric deposition on water quality and the resulting loss in recreational and other use and nonuse values: Given the limited information on the effects of changes in water quality on water basad recreation, the Council endorses the recommendation to limit efforts at quantification to the application of the National Acid Precipitation Assessment Program (NAPAP) model to New England and the Mid-Atlantic regions.

f) Valuing Changes in Crop Yields

There is a substantial literature on this topic, based largely on the crop yield results of the National Crop Loss Assessment Network research program. The IEc report cites the relevant literature. The Council endorses its recommendation to base the benefit estimate on a national agricultural model such as the U.S. Agricultural Sector model.

g) Valuing the Avoidance of Forest Decline

The IEc report in a good review of the relevant literature. Based on the reported results of the NAPAP *1990 Integrated Assessment Report* (NAPAP, 1991) calculations of hypothetical changes in forest growth rates, it appears that this category or benefits is likely to be quite small relative to other categories included in the assessment. The Council does not recommend significant additional effort on this category of benefits.

h) Valuing Damages to Materials

Although there is evidence that acid deposition causes damage to structural materials and coatings, there is not at present an adequate basis for calculating the economic costs associated with this damage. As the IEc report indicates, a panel of the EPA's Clean Air Scientific Advisory Committee (U.S. EPA, 1987) concluded that an earlier estimate of these damages was not reliable because of the lack of under-

standing of how people respond to the physical damages by repairing, replacing or re-coating damaged materials.

The other type of damage due to particulate and SO_2 pollution is the increase in household cleaning and maintenance expenditures. The IEc report recommends running the Mathtech model with current air quality data to estimate this category of benefits. This appears to be the only option unless significant primary research is undertaken. However the Council has reservations about the original Mathtech Model. The reservations have to do with the aggregate nature of the data used to estimate the model. The model estimates household spending on certain categories of goods as a function of differences in air pollution levels. But data are for households aggregated by Standard Metropolitan Statistical Area (SMSA) and the air quality data are also SMSA averages. This Council would have much more confidence in the results of the Mathtech Model if it could be re-estimated utilizing micro data household expenditures linked to specific measures of air pollution for each household observation.

Overall, the Council believes that these reports by IEc performed a useful function in providing an overview of the literature in the benefits area. To be of greater assistance to EPA, the most important additions to these studies would be more refined assessments of the merits of the past benefit studies and increased discussion of the open issues that have not yet been resolved in a manner that would provide EPA with a sound basis for benefit assessment.

The final version of the IEc report should also place greater emphasis on the areas where additional research is needed.

4) General Observations

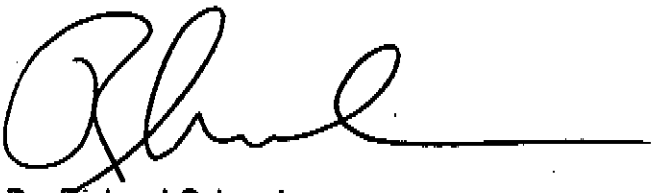
As we did in our earlier letter, we urge the Agency to involve the CAACAC as early as possible in the design and execution of the prospective study. No useful purpose is served by devoting substantial resources to executing a study based on assumptions, data, and methods that this Council may strongly believe are inferior to available alternatives or are unable to serve as the basis for credible estimates.

Finally, we note that on many complex issues EPA has used to advantage input from expert and affected parties at project initiation and at one or two points of

progress. CAACAC recommends that EPA consider doing this at the current phase of the retrospective study and continue into the prospective study. Specific modelling issues (e.g., how best to incorporate direct costs in a general equilibrium model) and factual questions (e.g., as stressed in our earlier letter, estimation of future direct compliance costs) could be addressed. The informal expert gatherings could be either continuing bodies or be convened in a series of workshops. Participants could include both stakeholder representatives and public interest groups having expertise. Some model efforts of such assemblages within EPA relate to product life cycle assessment and waste solidification. Some may feel seeking such input slows down progress, but in fact the increased chance of doing it right the first time usually speeds up studies.

We appreciate the opportunity to review the progress to date on the CAA impact analysis and look forward to receiving your response to the major points raised in this report.

Sincerely,



Dr. Richard Schmalensee
Chair
Clean Air Act Compliance Analysis Council

ENCLOSURES

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